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The Information Content of Discount Rate Announcements: What's Behind the Announcement Effect

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ABSTRACT

A considerable volume of research shows that asset prices respond to changes in the Federal Reserve's discount rate. While several competing hypotheses have been advanced to explain the market's response to discount rate announcements, comparatively little effort has been made to differentiate among alternative hypotheses. The result is an abundance of evidence establishing that asset prices respond to discount rate announcements, but little if any agreement about why markets respond. This article attempts to fill a void in the literature by pointing out how competing hypotheses differ and by constructing tests explicitly designed to differentiate among competing explanations. The evidence suggest that the market's reaction to discount rate changes is purely an announcement effect, i.e., a reaction to new information contained in the announcement, that the direct effect of discount rate changes on market rates is nil, that the announcement effect is invariant to the Federal Reserve's operating procedure and that, generally speaking, changes in the discount rate do not signal a change in monetary policy. The announcement effect appears to vary with both the nature and extent of the information that the announcement of a discount rate change is believed to contain.

KEYWORDS: Discount rate, federal funds, market efficiency

JEL CLASSIFICATION: E40, E52, G14

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"No simple rules govern the interpretations of changes in the discount rate."
— Ralph Young, "Tools and Processes of Monetary Policy," 1958.

The discount mechanism has been a focal point for many interesting monetary policy debates: the Fed's role as a lender of last resort, the real bills doctrine, the free reserves controversy, etc., and continues to occupy a prominent spot in monetary policy, as witnessed by the 11 discount rate changes since December 1990. Because discount rate changes are made infrequently, by sizable amounts, and are formally announced, they are newsworthy events that attract considerable attention. Indeed, often there is speculation about whether the Fed will change the discount rate and much significance is read into changes when they occur.

Given the intense interest in them and their high visibility, it is not surprising that considerable effort has been devoted to quantifying the effects of discount rate changes on interest rates, stock prices and the exchange value of the dollar [e.g., Waud (1970), Mudd (1979), Brown (1981), Thornton (1982, 1986, 1994), Roley and Troll (1984), Smirlock and Yawitz (1985), Batten and Thornton (1984, 1985), Cook and Hahn (1988), and Hakkio and Pearce (1992)]. While several hypotheses about why markets respond to discount rate changes have been advanced, comparatively little work has been devoted to distinguishing among them. The result is an abundance of evidence establishing that asset prices respond to discount rate changes, but little agreement about why markets respond.

One reason for the lack of a consensus is that various hypotheses are often advanced on their own merit. Researchers present evidence that is consistent with their hypothesis, but do not attempt to differentiate their hypothesis from equally compelling alternatives. This tendency is exacerbated by the lack of specificity about exactly how and why competing hypotheses differ and by the fact that some alternatives are observationally equivalent with respect to a given set of empirical evidence.

This paper attempts to fill this void by differentiating among alternative hypotheses of the effect of discount rate changes on market interest rates, and by presenting evidence from tests specifically designed to differentiate among competing hypotheses. In so doing, the literature is extended in a couple of other directions. First, the sample is extended to include the discount rate changes made under Chairman Greenspan. Since the level of discount window borrowing has been uncharacteristically small during the Greenspan era, the robustness of the existing empirical results over both time and the degree of reliance of depository institutions on the discount window is examined. Second, the effects of changes in the discount rate on the federal funds rate and on several Treasury rates are estimated to investigate the robustness of the response across interest rates. This is important because one recently advanced hypothesis [Cook and Hahn (1988)] relies on a close correspondence between the federal funds rate and other short-term interest rates, and because market efficiency requires that an announcement effect should be reflected in all rates simultaneously.

I. Alternative Theories of Why Market Interest Rates Respond to Discount Rate Changes

One reason for the relative dearth of attempts to reconcile the empirical literature on the effects of discount rate changes on market interest rates is that it is often difficult to see exactly how and why alternative hypotheses differ. For example, arguing that other market interest rates are tied to the federal funds rate through the expectations theory, Cook and Hahn (1988) hypothesize that market interest rates respond to discount rate changes because discount rate changes signal a change in the Fed's target for the federal funds rate. They argue that permanent changes to the level of the federal funds rate affect longer-term interest rates in a manner consistent with the expectations theory of the rate structure. Consequently, the market's response to a discount rate change is a direct consequence of the Fed's documented attachment [Goodfriend (1991)] to federal funds rate targeting in one form or another.

Roley and Troll (1984) also consider the impact of discount rate changes under federal funds rate targeting, but arrive at the opposite conclusion—discount rate changes have no effect on market rates when the Fed is targeting the funds rate. They argue that discount rate changes affect interest rates only when the Fed is targeting a reserve aggregate, like nonborrowed reserves. Although, Roley and Troll refer to this as an "announcement effect", the mechanism that they argue produces it is considerably different than the one that Cook and Hahn propose.

The most obvious difference is that Cook and Hahn assume that discount rate changes signal a change in the Fed's target for the federal funds rate, while Roley and Troll do not; but there is a more subtle, yet critical, difference. Specifically, Roley and Troll's hypothesis depends critically on the *direct effect* of a discount rate change on interest rates through its effect on borrowed reserves. Cook and Hahn's hypothesis, on the other hand, operates with or without a statistically significant direct effect: it depends solely on an expectational or announcement effect.

To see the difference between these two hypotheses it is useful to consider a standard representation of the market for reserves. The demand for reserves is given by

$$(1)\quad R^d = \tau f(i, \alpha), \quad f_1 < 0, f_2 > 0,$$

where f(i, α) represents the demand for reservable deposits, τ denotes the marginal reserve requirement, i denotes the short-term market interest rate and α denotes a vector other determinants of the demand for reservable deposits. The supply of reserves is given by the sum of the Fed's holdings of government securities, GS, and borrowed reserves, BR. The demand for borrowed reserves is given by

$$(2)\quad BR = h(FR - DR), \quad h' > 0,$$

where FR denotes the federal funds rate and DR denotes the discount rate. To close out the model, assume that short-term rates are related to the funds rate, i.e.,

$$(3)\quad i = \theta(FR), \ \theta' > 0.$$

Differentiating the reserve market equilibrium condition and solving for $\partial i/\partial$DR yields

$$(4)\quad \partial i/\partial DR = (h'\ \theta' - \theta' dGS/dDR)(h' - \tau f_1 \theta')^{-1}.$$

The direct effect of a discount rate change occurs when the Fed does nothing to offset its effect on the federal funds rate, i.e., when dGS/dDR = 0. Hence, the direct effect is,

$$(5)\quad \partial i/\partial DR = h'\theta'/(h' - \tau f_1 \theta') > 0.$$

Note that equation 5 is simply $\theta'\partial$FR/∂DR. When the Fed targets the funds rate at some level, FR*, it does so by setting its portfolio of government securities equal to

$$(6)\quad GS^* = \tau f(\theta(FR^*), \alpha) - h(FR^* - DR).$$

Roley and Troll argue that if the Fed is targeting the federal funds rate, it will automatically offset the direct effect of its discount rate action on borrowing through compensating open market operations. That is, they assume that $dGS^*/d\mathrm{DR} = -h'$, so that $\partial i/\partial \mathrm{DR} = 0$. Specifically, Roley and Troll (page 33) note that under a federal funds rate operating procedure "an increase in the discount rate...would result in nonborrowed reserves increasing" to keep the funds rate at its target level. Alternatively, "Under a nonborrowed reserves operating procedure, a discount rate change would be expected to affect interest rates *without any further overt policy actions*" (pages 33-4, emphasis added). Hence, Roley and Troll argue that changes in the discount rate affect market interest rates through the direct effect unless the Fed acts to offset it. Consequently, an empirically significant direct effect is the essential element of their hypothesis.

The essential feature of Cook and Hahn's hypothesis, however, is Equation 3, i.e., $i = \theta(\mathrm{FR}^*)$. They argue that a change in the discount rate signals a change in the Fed's target for the federal funds rate: other rates respond to the perceived change in the rate structure. This would occur, even if $h' \neq 0$, or equivalently, if the discount window were closed![1] Hence, if the direct effect of discount rate changes is nil, Roley and Troll's hypothesis is rejected, but Cook and Hahn's is not. Consequently, the first step in unraveling why interest rates respond to discount rate changes is to see whether it is possible to distinguish between the direct effect and the announcement effect hypotheses.

II. Is There A Direct Effect Of a Discount Rate Change?

The fact that $h' \neq 0$ creates the possibility for a direct effect. A *prima facia* case can be made, however, that the direct effect might be so small as to be statistically insignificant. Recently Pagan and Robertson (1995) have shown, over the period 1959 through 1993, that it takes about a 1 percentage point increase in the average level of nonborrowed reserves to produce about a 13 basis point decline in the federal funds rate at the monthly frequency. Moreover, both they and Christiano (1995) show that the effect of an exogenous change in nonborrowed reserves has been essentially non existent since the early 1980s. The direct effect depends directly on h', which has been relatively small. Based on Pagan and Robertson's estimates, it would take approximately a 5 percentage point cut in the discount rate to produce about a 13 basis point decline in the federal funds rate, even using a very large estimate

[1] It is nevertheless true that it would be easier to effect a change in the funds rate through the discount rate, the larger is $h' = 0$. A discount rate change that signals a change in the funds rate target requires additional open market operations be undertaken to bring the funds rate to its new target level. This is required because $\partial i/\partial \mathrm{DR} = 1$ if and only if $= \tau f_1\, \theta'(1-\theta')^{-1}$. But this requires h' to be large, especially if θ' is large. However, the evidence [Polakoff (1960), Goldfeld and Kane (1966), Polakoff and Silber (1967), Tinsley, et. al. (1982), Thornton (1986) and Clouse (1990, 1994)] is overwhelming that h' is significantly less than unity. Hence, Cook and Hahn are assuming that, under a funds rate targeting procedure, the Fed will undertake additional actions to raise the funds rate to the new target level. In contrast, Roley and Troll assume that the Fed will undertake opposite actions to offset the direct effect of the discount rate change.

of h' of about 0.4. Moreover, the interest sensitivity of borrowing has itself become much smaller in the 1980s [e.g., Clouse (1990, 1994)]. Since the mid-1980s, the direct effect should essentially be nil because $h' \approx 0$.

A. The Existing Evidence of a Direct Effect

Much of the existing evidence points to a statistically insignificant direct effect. For example, it is well established [Thornton (1982, 1986), Smirlock and Yawitz (1985), Cook and Hahn (1988), Dueker (1992) and Batten and Thornton (1984, 1985)] that asset prices respond only to discount rate changes that the Fed announces are made for other than technical reasons, i.e., for reasons other than simply to keep the discount rate in line with market interest rates. However, all discount rate changes, regardless of the motivation for them, should have a direct effect. Consequently, evidence that markets respond only to non-technical discount rate changes suggests that the direct effect is nil.[2]

In addition, Thornton (1986) has shown that markets respond to discount rate changes even during periods when the discount rate is a "penalty rate," i.e., when the discount rate is above other market interest rates. At such times borrowing is small and should be relatively interest insensitive, so the direct effect should be small.

The differential response of asset prices to technical and non-technical discount rate changes, however, could stem from technical changes being anticipated while non-technical changes are not. Moreover, that markets respond to non-technical discount rate changes when the discount rate is a penalty rate merely suggests that there is also an announcement effect: it does not necessarily imply that there is no direct effect. Consequently, the above evidence is suggestive, but not conclusive.

Although limited, evidence on the predictability of discount rate changes suggests that technical changes in the discount rate are no more predictable than non-technical changes. For example, Hakkio and Pearce (1992) report some in-sample success in predicting discount rate changes prior to October 1979 using a Logit model. An examination of their results, however, suggests that technical changes generally were no more predictable than non-technical changes. Likewise, Dueker (1992) found that the timing of discount rate changes were difficult to predict,

[2]Note this point is not negated by Cook and Hahn's (1988) hypothesis. If non-technical changes in the discount rate signal a change in the Fed's target for the federal funds rate, changes in the discount rate would not give rise to a change in the spread between the federal funds and discount rates if the funds rate target were adjusted point-for-point with the discount rate. In these instances there could be no direct effect on market rates. Technical discount rate changes, on the other hand, would have a direct effect since the federal funds rate would not automatically move point-for-point with technical realignments of the discount rate.

even at a weekly frequency, and that the distinction between anticipated and unanticipated was unimportant in determining movements in the three-month Treasury-bill rate in response to discount rate changes.

The most compelling evidence that the differential response to technical and non-technical discount rate changes is due to the predictability of the former is Smirlock and Yawitz's (1985) result that the response of interest rates to "unanticipated" discount rate changes using the technical/non-technical classification based on the statements of the Board of Governors were nearly identical to those using anticipated/unanticipated discount rate changes from a statistical model. Smirlock and Yawitz interpret their finding of a statistically significant, positive correlation between like-classified discount rate changes using the two methods as evidence that technical discount rate changes have no effect on the markets because they are anticipated.[3]

B. Some Additional Tests of the Direct Effect Hypothesis

Additional evidence on the importance of the direct effect can be obtained from tests of four basic types. The first type is a test of Roley and Troll's argument that the Fed did not offset the direct effect of interest rates when it was targeting nonborrowed reserves. If they are correct and there is a direct effect, the magnitude of the response to discount rate changes should be larger during the period from October 1979 to October 1982 when the Fed was explicitly targeting nonborrowed reserves. At that time, the Fed would have no particular reason to offset the direct effect of a discount rate change on market rates.[4] Moreover, the response should be invariant to the type of discount rate change, assuming of course that both technical and non-technical discount rate changes are equally predictable.

Conversely, if, as Cook and Hahn suggest, non-technical discount rate changes signal a change in the target for the funds rate, while technical changes do not, the response to non-technical changes should be larger when the Fed is targeting the federal funds rate than when it is targeting reserves. In the former case both the announcement and direct effects would be operative, while in the latter case only the direct effect would matter. Hence, additional evidence on the importance of the direct effect can be obtained by investigating the magnitude of the response to technical discount rate changes over periods of federal funds and nonborrowed reserve targeting.

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[3]Several authors, including Batten and Thornton (1984, 1985), have suggested this interpretation based solely on the fact that markets respond only to unanticipated discount rate changes.

[4]For a discussion of changes in the Fed's operating procedure see Feinman (1994), Feinman and Poole (1989) and Thornton (1988).

The second type of test is a direct test of predictability. If technical changes are more predictable than non-technical changes, they should be more readily explained by the past behavior of other variables. Two types of direct tests of predictability are conducted. The first extends the work of Smirlock and Yawitz (1985). Reexamining Smirlock and Yawitz's result is important because they provide the most compelling evidence that the failure of the market to respond to technical discount rate changes may be due to their being anticipated.

A second direct test of predictability uses daily data to determine whether technical discount rate changes are more predictable than non-technical changes based on the past behavior of interest rates alone.

The estimated equation is

$$(7)\quad \Delta i_t \;=\; \alpha + \mu(L^{-1})\Delta DR_{T,t} + \lambda(L^{-1})\Delta DR_{NT,t} + \epsilon_t,$$

where Δi_t is the change in a market interest rate, $\mu(L^{-1})$ and $\lambda(L^{-1})$ are polynomials of order k, [e.g., $\mu(L^{-1}) = \mu_1 L^{-1} + \mu_2 L^{-2} + \ldots + \mu_k L^{-k}$, in the lead operator, L^{-1}] and ΔDR_T and ΔDR_{NT} denote technical and non-technical discount rate changes, respectively. The null hypotheses $\mu(L^{-1}) = \lambda(L^{-1}) = 0$ can be tested for various values of k. Rejecting the null hypothesis that $\mu(L^{-1}) = 0$, but not the null that $\lambda(L^{-1}) = 0$ would support the idea that technical changes are more easily anticipated than non-technical changes.

The third type of test is an indirect test of predictability. Its motivation comes from noting that there are really two distinct types of non-technical discount rate changes, those which include a technical component and those which do not. If the market does not respond to technical discount rate changes because they are predictable, it is reasonable to conjecture that the market's response to discount rate changes that have a technical component should be smaller than those that do not. This possibility is investigated by testing the hypothesis that the market's response to purely non-technical discount rate changes is equal to that of mixed technical and non-technical discount rate changes against the alternative that the response to purely non-technical changes is larger than the response to mixed changes.

The fourth type of test utilizes the fact that the direct effect varies directly with the interest responsiveness of borrowing. The test is motivated by Figure 1, which shows monthly adjustment borrowing, seasonal borrowing and the spread between the federal funds and discount rates for the period January 1973 to January 1993.[5] There are several interesting features of Figure 1. First, while adjustment borrowing is very sensitive to the spread between the federal funds and discount rates, seasonal borrowing appears to be much less so. Second, since the mid-1980s, adjustment borrowing has become small. Increasingly total borrowing has been dominated by seasonal borrowing. Third, and somewhat less obvious, is the fact that adjustment borrowing has been less interest sensitive since at least the mid-1980s.

The fact that borrowing has become small and relatively unresponsive to changes in the rate spread can be used to identify whether the response of interest rates to non-technical discount rate changes is due to a direct or an announcement effect. Equation 5 shows that the direct effect varies directly with the interest sensitivity of borrowing. Consequently, if the direct effect is important, the response of market rates to changes in the discount rate should be much smaller during the period since the mid-1980s, when the response of borrowing to a change in the discount rate is small and statistically insignificant. A failure to find a statistically significant drop in the response of market rates to non-technical changes in the discount rate in the latter period, compared with the former, would suggest that the direct effect is not statistically significant. This test has the advantage that it involves only non-technical discount rate changes, so it is not subject to the anticipated/unanticipated distinction that arises in comparisons of the market's response to technical and non-technical discount rate changes.

C. The Data

The data on interest rates are daily for the period January 3, 1972 to January 29, 1993. The change in the discount rate is the percentage-point change in the discount rate on the day that a discount rate change was first announced. Four market interest rates are used: the federal funds rate, FR, and the three-, six-, and 12-month Treasury rates, TR3, TR6 and TR12. FR is the weighted average rate on daily transactions for a group of federal funds brokers and is compiled by the Federal Reserve Bank of New York. The Treasury rates are rates taken at "market close," about 4:00 p.m. E.S.T. Discount rate changes are aligned with changes in market interest rates so that the change in the relevant rate can reflect announcements of discount rate changes.

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[5]The seasonal and extended credit borrowing programs came into existence in 1973. Consequently, no distinction was made between seasonal and adjustment borrowing prior to May 1973.

The discount rate changed 63 times during this period. Following Thornton (1982), discount rate changes are classified as technical, ΔDR_T, or non-technical, ΔDR_{NT}, depending on whether the Fed's announcement stated that the change was made solely to keep the discount rate in line with market rates or gave some other reason for the change. Using this classification, there were 23 technical discount rate changes and 40 non-technical changes. The latter group can be further partitioned into those that are purely non-technical, i.e., the statement that the discount rate is changed to bring it into alignment with market interest rates is not given as one of the reasons for the change, and mixed technical and non-technical, i.e., discount rate changes that are made for both technical and other reasons. The dates and magnitude of discount rate changes and the corresponding changes in the four market interest rates are presented in Table 1, where discount rate changes are also identified as technical, T, purely non-technical, P, or mixed technical and non-technical, M.

It is well-known that the volatility of interest rates was unusually high during the period from October 1979 to October 1982 when the Federal Reserve was targeting non-borrowed reserves. In addition, the variability of the federal funds rate increases significantly on settlement Wednesdays and on the first and last day of the year. The volatility of the federal funds rate also rose significantly for a short period following the Board of Governors' decision in December 1990 to eliminate reserve requirements on all non-transactions deposits.[6] The consideration of heteroskedasticity is potentially important because a given response to a discount rate change may be statistically significant or not depending on whether it occurred during a period of low or high interest rate volatility.[7] In the regressions reported here heteroskedasticity is explicitly modelled.[8]

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[6]This reserve requirement change was not telegraphed to banks and many found their deposit balances at the Fed fall below the level necessary to service their daily transactions. The funds rate was unusually volatile while banks sorted things out. This increased volatility of the funds rate did not carry over into the Treasury-bill rates, however.

[7]A comparison of studies that only utilize observations on the day that discount rate changes occurred, e.g., Smirlock and Yawitz (1985), Roley and Troll (1984), Cook and Hahn (1988) and Wagster (1993), with those that utilize all daily observations on interest rates, Thornton (1982, 1986), suggests that most of the qualitative conclusions are not affected by this consideration. The exception is reflected in the recent work of Wagster (1993) who attempts to account for the disparity in the results of Cook and Hahn and those of Smirlock and Yawitz and Roley and Troll: the former find a significant market reaction to non-technical discount rate changes prior to October 1979, while the latter do not. Wagster surmises that the disparity in the results is due to the fact that the five discount rate changes made in 1973-74 were included in the former's sample, but not in the latter's. Partitioning the data into sub-samples, Wagster finds no statistically significant response of the TR3 to non-technical changes in the discount rate for either the Smirlock and Yawitz or Roley and Troll sample periods. He attributes the difference in the response for the periods 1973-74 and 1975-79 to an unspecified change in "the Federal Reserve's discount policy." The result that TR3 does not respond significantly to non-technical discount rate changes in either of these periods is due to not appropriately accounting for the heteroskedasticity. While the response is smaller during the 1975-79 period, it is statistically significant.

[8]For ΔFR the variance was permitted to be different on settlement Wednesdays and Thursdays (an inordinate change on a settlement Wednesday spills over to Thursday) and during the first and last day of the year. The periods for modelling the heteroskedasticity were chosen from the residuals from regressions of each rate on a constant and technical and non-technical changes in the discount rate. The final estimates were made

D. The Results

To test the hypothesis of whether the market's response to discount rate changes was larger during the period of non-borrowed reserve targeting, the equation

$$(8)\quad \Delta i_t = \alpha + \beta(L)\Delta i_{t-1} + \delta(L)\Delta FR_t + \mu^j_{NT}\,\Delta DR^j_{NT} + \mu^j_T\,\Delta DR^j_T + \epsilon_t\ ,\ j= \begin{cases} 1 \text{ if } 1/3/72 \le t \le 10/8/79 \\ 2 \text{ if } 10/9/79 \le t \le 10/11/82 \\ 3 \text{ if } 10/12/82 \le t \le 1/29/93 \end{cases}$$

was estimated, where Δi is the change in one of the four interest rates and $\beta(L)$ and $\delta(L)$ are n^{th}-order polynomials of the form, $\beta(L) = \beta_0 + \beta_1 L + \beta_2 L^2 + ... + \beta_n L^n$, in the lag operator, L.[9] $\delta(L)\Delta FR$ was included because the effect of a change in the discount rate on market rates is conditional on the funds rate. Of course, when $i \equiv FR$, $\delta(L)$ is set to zero.

The consideration of the variability of interest rates is particularly important for testing whether the response to discount rate changes is larger during the period of nonborrowed reserve targeting. Not only was there greater variability about the mean change in interest rates during this period, but the mean absolute change in interest rates was much larger during this period as well. This is shown in Table 2 which presents the average absolute changes in the four interest rates on days when there were no discount rate changes for periods before, during and after nonborrowed reserve targeting. The average absolute change in the interest rates is more than 2.75 times larger during the nonborrowed reserve targeting period than for the periods before or after.

Given the difference in average absolute changes in rates over these periods, it would hardly be surprising to find that the change in interest rates corresponding to a percentage-point change in the discount rate were larger during the nonborrowed reserve targeting period. Indeed, estimates of Equation 8, presented in Table 3, yield precisely this result for non-technical discount rate changes. A comparison of the relative magnitude of the estimated coefficients during the nonborrowed reserve targeting period with those of the periods before and after suggests that

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with a two-step generalized least squares, GLS, procedure, e.g., see Fomby, Hill and Johnson (1984, pp. 174-76). The estimated standard errors for the various sub-periods are reported with the regression results.

[9] $\beta(L)$ is included in this and all other regressions to control for the effects of past information on the interest rate. In every case n = 10, although none of the coefficients are reported. The qualitative results are insensitive to whether the distributed lag of the dependent variable is included.

the relative magnitude of the response is roughly on the order of the relative magnitude of the average absolute changes in the rates over these periods presented in Table 2. Hence, measured relative to the average change in the rates during these periods, the response to a non-technical discount rate change appears to be no larger during the period when the Fed was targeting nonborrowed reserves.

This observation is confirmed by the results of estimates of Equation 8, presented in the bottom portion of Table 3, where the change in the interest rate has been adjusted by the average absolute change in the rate for each period.[10] Generally speaking, the coefficients for the nonborrowed reserve targeting period are somewhat larger than those for the period of funds rate targeting prior to October 1979; however, they are somewhat smaller than those of the period of funds rate targeting after October 1982 for the Treasury-bill rates, both absolutely and relative to their standard errors. The evidence does not support the hypothesis that the response of market rates to non-technical discount rate changes was larger during the period of nonborrowed reserve targeting.[11] Hence, the results do not support the notion of an empirically important direct effect.

Moreover, the results strongly support previous research [Thornton (1982, 1986, 1994), Smirlock and Yawitz (1985) and Cook and Hahn (1989)] that markets do not respond to discount rate changes that the Fed announces are made solely to keep the discount rate in line with market interest rates.[12] This result is robust, holding up over the extended sample and over the separate periods. The fact that the markets did not respond to technical discount rate changes during the nonborrowed reserves targeting period is further support for the notion that the direct effect is nil.

Results of the two direct tests for predictability of technical and non-technical discount rate changes are presented in Table 4. The upper half of the table reports the results from the model used by Smirlock and Yawitz

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[10]This interpretation is also supported by a comparison of the t-statistics for these coefficients which suggests that the size of the coefficient relative to its variability was not significantly different during the October 1979 - October 1982 period.

[11]The result that the markets response to non-technical discount rate changes has been somewhat larger since October 1982 is somewhat of an anomaly. One possibility is the increased attention that monetary policy has received with the large federal deficits and the demise of activist fiscal policy.

[12]The third period omits the technical discount rate change that was made on October 12, 1982. Consistent with Thornton (1986), the coefficient μ_T is statistically significant only for the Treasury rates when this observation is included. This is true whether technical discount rate changes are partitioned, as they are here, or not. In any event the statistically significant response of Treasury-bill rates to technical discount rate changes is due entirely to the technical discount rate change on October 12, 1982. When this observation is deleted μ_T is not significantly different from zero for any of the four interest rates. This discount rate change was made only two days after the Fed announced its decision to de-emphasize M1 as an intermediate policy target. Thus, the market appears to have attributed some significance to this change, despite the Fed's announcement that the move was taken solely to bring the discount rate in line with market rates.

(1985).[13] Following Smirlock and Yawitz, discount rate changes are regressed on four lags of (a) the spread between the federal funds rate and the discount rate and (b) borrowing from the Federal Reserve. Since borrowing is only available weekly, weekly averages of daily data are used. A comparison of the adjusted R^2 for these equations suggests that technical discount rate changes are slightly more predictable than non-technical changes. Moreover, the coefficients on the spread variable and borrowing are generally more significant for technical changes. While the F-statistic for the test of the significance of the slope coefficients is statistically significant in both specifications, the adjusted R-squares are very small. Consequently, neither technical nor non-technical changes appear to be very predictable. Indeed, unanticipated changes in the discount rate generated from this model differ little from actual discount rate changes.

The relatively poor performance of the model explains why Smirlock and Yawitz found little difference in the market's response to technical and non-technical discount rate changes based on the press releases of the Fed and unanticipated discount rate changes estimated from their model. Because of the model's poor performance, the residuals from the statistical model are essentially the actual changes in the discount rate—both technical and non-technical. Since the markets do not respond to technical discount rate changes, it is hardly surprising that the coefficient response to unanticipated discount rate changes from their statistical model was essentially the same as that of non-technical changes. The coefficient on unanticipated changes in the discount rate is the sum of the coefficients on non-technical discount rate changes and technical discount rate changes; the latter coefficient being very close to, and statistically insignificantly different from, zero. Consequently, Smirlock and Yawitz's result, that the markets response to non-technical changes is essentially the same as to unanticipated changes from their model, is not compelling evidence that technical discount rate changes are anticipated while non-technical changes are not.

Tests of predictability based solely on interest rates are reported in the lower half of Table 4. These results suggest that the differential response of market interest rates to technical and non-technical discount rate changes is not due to the greater predictability of technical discount rate changes. Joint tests of the lead coefficients are generally significant for both technical and non-technical discount rate changes when the Treasury-bill rates are used.

[13]Smirlock and Yawitz (1985) claim that this was the best of several alternative specifications that they tried. Consequently, this specification was used. I attempted to replicate their results; however, their description of what they did lacked detail. Using periods that contained the number of discount rate changes that they said they had in each period, I constructed samples of sizes identical to those reported in their paper. I obtained results that were fairly close to theirs, but was unable to replicate their results.

This result likely reflects the tendency of all discount rate changes—technical and non-technical—to follow rather than lead market interest rates.[14] The tests are usually significant only for non-technical discount rate changes for the federal funds rate.

The finding that neither technical nor non-technical discount rate changes is very predictable is not as surprising as it may seem. The Fed's behavior with respect to discount rate changes has been erratic. The discount rate has been raised when the spread of the funds rate over the discount rate was very narrow, while at other times a spread of 300 basis points or more has failed to provoke even a technical discount rate adjustment. In any event, it would be difficult to anticipate the precise day of a discount rate change, so all discount rate changes should have an important unanticipated component.

To test whether markets respond equally to pure and mixed non-technical discount rate changes, the equation

$$(9)\quad \Delta i_t \;=\; \alpha + \beta(L)\Delta i_{t-1} + \delta(L)\Delta FR_t + \mu_P \Delta DR_{P,t} + \mu_M \Delta DR_{M,t} + \epsilon_t,$$

is estimated for the entire sample. Estimates of Equation 9 are reported in Table 5. Differences in the response to pure non-technical and mixed discount rate changes are quite small and the null-hypothesis, $\mu_P - \mu_M = 0$, is not rejected for any of the four rates.[15] These results suggest that the differential response of markets to technical and non-technical discount rate changes is not due to the former being anticipated. Because the market's response is the same to pure non-technical and mixed discount rate changes, no distinction is made between them for subsequent tests.

To see whether the response of interest rates to non-technical discount rate changes varies directly with the interest responsiveness of borrowing, we first estimated the borrowing equation,

$$(10)\quad Borr_t \;=\; \lambda_0 \;+\; \lambda_1 (FR - DR)_t \;+\; \lambda_2 (FR - DR)_t^2 \;+\; \epsilon_t,$$

[14]It is interesting to note that Garfinkel and Thornton (1995) found that changes in the federal funds rate tend to follow rather than lead changes in the three-month Treasury-bill rate.

[15]Cook and Hahn (1988) also partitioned non-technical discount rate changes into pure non-technical and mixed. Consistent with the findings here over a much longer sample, in a footnote they report finding no statistically significant difference in the response of the federal funds rate to these two types of non-technical discount rate changes.

where Borr is alternately adjustment borrowing and seasonal borrowing. Estimates of Equation 10 for periods before and after June 1984 are presented in Table 6.[16] June 1984 was chosen as the break point in the borrowing function because Clouse (1992, 1994) presents evidence that suggests that the change in borrowing behavior was due to large banks staying away from the discount window in the wake of Continental Illinois' problems and its large borrowing from the Fed. As expected, the coefficient on the rate spread is much smaller for seasonal than for adjustment borrowing, however; it is statistically significant during the first period. Estimates of the adjustment borrowing equation shows a significant change in the behavior of both seasonal and adjustment borrowing, with the interest responsiveness being much smaller and not statistically significant after mid-1984.

To test whether the response to non-technical discount rate changes varies directly with the interest sensitivity of borrowing, the equation

$$(11) \quad \Delta i_t = \alpha + \beta(L)\Delta i_{t-1} + \delta(L)\Delta FR_t + \mu\Delta DR_{NT,t} + \epsilon_t,$$

was estimated over periods before and after June 1984. The results are reported in Table 7. All of the coefficients are statistically significant and, generally speaking, the differences in the magnitude of the response are small. More important, they are not statistically significant. The finding that the response of interest rates to non-technical changes in the discount rate is the same for both periods supports the conclusion that the market's response to non-technical discount rate changes does not vary directly with the interest sensitivity of borrowing as would be expected if the direct effect were empirically important.[17]

III. What's Driving the Announcement Effect?

Statistical evidence is never conclusive. The evidence presented here, however, combined with previous evidence, overwhelmingly supports a single conclusion: the direct effect is nil—the market's reaction to non-technical discount rate changes is a pure announcement effect. But what's behind the announcement effect? Broadly speaking, two competing announcement effect hypotheses have been offered. The first, suggested by Friedman

[16]The seasonal borrowing equation included two lags of borrowing and 11 monthly seasonal dummy variables.

[17]The data in Table 2 suggests that the average absolute change in market interest rates is larger during the period prior to June 1986 than the period since. Consequently, a comparison of the estimated coefficients not adjusted for the mean differences is not appropriate. Note, however, that the adjustment for average absolute change in the interest rates over these periods will raise the estimated coefficient for the post-June 1986 period relative to the pre-June period.

(1959), views discount rate changes as the administrative actions of a monetary authority who is in a unique position to judge the course of economic activity or interest rates. Markets are hypothesized to respond to the new information about the course of interest rates or economic activity, whether the Fed is responsible for the course or not.[18]

The second hypothesis argues that discount rate changes signal a change in monetary policy. A rise in the discount rate is seen as a shift in monetary policy toward restraint, while a decrease is seen as a shift toward ease. These competing announcement effect hypotheses are distinguished by the fact that the second implies that non-technical discount rate changes signal that the Fed will do something different with respect to monetary policy, while the first does not. Consequently, these competing hypotheses can be distinguished by investigating whether non-technical discount rate changes signal a change in monetary policy.

Unfortunately, no consensus exists about the appropriate indicator of monetary policy. The Fed's pre-occupation with the federal funds rate [Goodfriend (1991)] has motivated many researchers [e.g., Bernanke and Blinder (1992), Christiano and Eichenbaum (1991, 1992a, b), Friedman and Kuttner (1993), Kashyap and Stein and Wilcox (1993) and Laurent (1988)] to use it as an indicator of policy.

Alternatively, changes in monetary policy should be reflected in aggregates that reflect the actions of the Fed—primarily, open market operations. Several such aggregates have been suggested. The most notable of these are the adjusted monetary base, total reserves adjusted for reserve requirement changes, and non-borrowed reserves. The adjusted monetary base was designed to summarize all of the policy actions of the Fed into a single measure. Critics argue that the base is largely made up of currency, which is supplied elastically, so fluctuations in it may be due more to shifts in currency demand (even foreign demand) than to changes in monetary policy. Since neither total reserves nor nonborrowed reserves include currency, they are not affected by shifts in currency demand. Indeed, since currency is supplied elastically, the Fed tends to keep reserves constant in the face of shifts in the demand for currency.

Christiano and Eichenbaum argue that nonborrowed reserves is a better indicator of monetary policy than total reserves because it eliminates the endogenous borrowing component from total reserves. Also, their results

[18]See Friedman (1959) and Waud (1970) for discussions of this view.

using innovations to nonborrowed reserves or the funds rate are so similar that the two measures are interchangeable as policy indicators. This suggests that nonborrowed reserves can be used as a proxy for the funds rate. As support for their view, they point out that there is a liquidity effect for nonborrowed reserves but not for total reserves. Christiano and Eichenbaum's finding has been challenged [Coleman, Gilles and Labadie (1995) and Pagan and Robertson (1995)]. Nevertheless, the adjusted monetary base, total reserves and nonborrowed reserves are all used as indicators of monetary policy along with interest rates to test whether non-technical discount rate changes signal a change in monetary policy.

A. Existing Evidence of an Announcement of a Change in the Federal Funds Rate Target

Cook and Hahn (1988) hypothesize that the market interprets a non-technical discount rate change as a signal that the Fed has changed its target for the federal funds rate. Other short-term interest rates change with the change in the funds rate in accordance with the expectations theory of the term structure. To test their hypothesis, Cook and Hahn estimated the response of the federal funds and three-month Treasury-bill rates by estimating the response of these rates over 91- and 182-day periods to non-technical changes in the discount rate. Interpreting these changes as *permanent*, they conclude that changes in the discount rate signal permanent changes in the Fed's target for the federal funds rate.

Thornton (1994) has pointed out that in their analysis, the alternative hypothesis—discount rate changes have a *temporary* effect on the level of the funds rate—is not feasible. Decomposing Cook and Hahn's 91- and 182-day changes in market rates into the initial one-day response and the subsequent response Thornton has shown that all of the "permanent response" occurs immediately. Thornton argues that if Cook and Hahn's interpretation were correct, the response of market interest rates to changes in the discount rate should be faster during periods when the Fed was directly targeting the federal funds rate than during periods when it is targeting funds rate “indirectly”, i.e., targeting either nonborrowed or borrowed reserves [Goodfriend (1991) and Thornton (1988)]. However, he shows that the response to non-technical changes in the discount rate occurs immediately during both the direct and indirect targeting periods. Consequently, Cook and Hahn's results provide no evidence of their hypothesis and further tests do not support it.

B. Additional Evidence of an Announcement Effect of a Change in the Federal Funds Rate Target

It is possible to test the hypothesis that non-technical changes in the discount rate signal changes in monetary policy as reflected in the behavior of the federal funds rate with a modified version of Cook and Hahn's hypothesis. Specifically, it is hypothesized that non-technical changes in the discount rate signal changes in the Fed's path for the federal funds rate and, consequently, the path for other interest rates. For example, if interest rates have been falling and the discount rate is raised, rates should rise. If rates have been rising and the discount rate is cut, rates should fall. Interest rates typically drift up or down prior to a change in the discount rate in the same direction, however, so it is extremely unlikely that there will be reversals in the path of interest rates following discount rate changes. It is possible, however, to test whether non-technical changes in the discount rate signal changes in the path for the federal funds rate and other rates by testing for a significant shift in the drift of interest rates before and after non-technical discount rate changes. This can be done by estimating the equation

$$(12)\quad \Delta i_t = \alpha + \beta(L)\Delta i_{t-1} + \delta(L)\Delta FR_t + \lambda_b\, DRIFT_{k,b} + \lambda_a\, DRIFT_{k,a} + \epsilon_t ,$$

where $DRIFT_{k,b}$ is a dummy variable that takes on the value one k days before non-technical discount rate changes and zero otherwise and $DRIFT_{k,a}$ is a dummy variable that takes on the value one on the day of a non-technical discount rate change and k-1 days after the change and zero otherwise. Including the day of the discount rate change announcement in the second drift variable for the Treasury-bill rates is reasonable since the market's reaction to discount rate announcements should reflect expectations for the overnight rate. It could bias the results in favor of finding a significant shift in the drift for the federal funds rate, however.

Estimates of Equation 12 for the federal funds rate for four values of k, 5, 10, 15 and 20, are reported in Table 8. Because interest rates have drifted both up and down, the drift variable is partitioned for positive and negative changes in the discount rate. In nearly every instance, the estimated drift coefficients before non-technical changes in the discount rate are correctly signed and are statistically significant, confirming that the federal funds rate moves in the direction of non-technical discount rate changes prior to the announcement. The results indicate a significant shift in the drift of the federal funds rate following non-technical discount rate changes in the same direction. The absolute value of the estimated post-change drift coefficient tends to get smaller as k increases, suggesting that the significant difference in the drift coefficients could be due to the initial reaction of markets to the discount rate announcement.

To test this, the funds rate equation was reestimated for k days before and k days after non-technical changes in the discount rate. These results, reported in Table 9, generally confirm the impression that the significance in the change in the trajectory for the funds rate, reported in Table 8, is strongly influenced by the immediate response of the funds rate to discount rate changes. The null hypothesis of no significant shift in the drift is rejected only for discount rate increases and for small values of k. On net, the evidence for the overnight rate supports the conclusion that non-technical changes in the discount rate are associated with an immediate change in the level of the funds rate, but no change in its trajectory.

The results for the Treasury-bill rates, presented in Table 10, also support the conclusion of no significant shift in the path for market rates. In virtually every instance, the estimated drift coefficients for non-technical discount rate changes are correctly signed and statistically significant at the 5 percent level. It is frequently the case that the absolute value of the estimated post-change drift coefficient becomes smaller rather than larger, as would be the case if changes in the discount rate signaled a change in the trajectory for interest rates. In any event, there was only one instance when the null hypothesis of no significant shift in the drift was rejected and this was in the "wrong" direction.[19] To the extent that changes in the path of interest rates are taken to be an indicator of changes in the stance of monetary policy, the lack of a change in the trajectory of interest rates suggests that non-technical discount rate changes do not signal a change in the stance of monetary policy.

Similar tests for a significant change in monetary policy were performed using the growth rates of reserve aggregates—the adjusted monetary base, total reserves and nonborrowed reserves. Data on the adjusted monetary base are weekly, while the data on total reserves adjusted for reserve requirement changes and nonborrowed reserves

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[19]The results for the federal funds and Treasury-bill rates are difficult to reconcile with the expectations theory of the term structure. Goodfriend (1991) and Cook and Hahn (1988, 1989) argue that the longer-term bill rates are equal to the holding-period expectation of the overnight funds rate. Hence, it is reasonable that non-technical changes in the discount rate permanently raise the levels of both rates. However, a significant rise in the level of market rates should result in a significant change in the trajectory of rates at short horizons. Moreover, the point estimates of the response of the funds and Treasury-bill rates to discount rate changes are inconsistent with a strict interpretation of the expectations theory and this explanation does not account for the significant drift in rates prior to discount rate changes. An alternative hypothesis, predicated on the observation that the federal funds rate tends to follow the T-bill rates, e.g., Garfinkel and Thornton (1995), and the fact that the Fed appears to make discrete adjustments in its target for the funds rate, is that the Fed merely adjusts its funds rate target to major swings in nominal interest rates that the Fed itself is not responsible for. Still another conjecture is that non-technical discount rate changes confirm changes in the Fed's policy toward interest rates that had been undertaken earlier. Neither of these hypotheses accounts for the response of interest rates to non-technical discount rate changes, however.

are maintenance-period data—weekly prior to February 1984 and bi-weekly thereafter. Changes in the growth rates of these aggregates were regressed on dummy variables for five weeks or five maintenance periods prior to and after changes in the discount rate.[20]

Though interesting, the results, presented in Table 11, do not support the hypothesis that non-technical discount rate changes signal a change in monetary policy. For the monetary base, all of the drift coefficients are statistically significant, but the null hypothesis of the equality of the drift coefficients is not rejected. Moreover, the growth rate of the monetary base accelerates following an increase in the discount rate rather than decelerate as expected.

The results for nonborrowed reserves are in the anticipated direction, i.e., increases in the discount rate are associated with decelerations in reserves growth and discount rate cuts are associated with accelerations in reserve growth, but the coefficient estimates are generally not statistically significant. The results for total reserves are similar to those of nonborrowed reserves, except that change in the direction of growth of total reserves is the wrong sign in the case of a discount rate increase.

While these results provide some qualitative support for the hypothesis that non-technical discount rate changes signal a change in monetary policy, they do not provide statistical support for this interpretation. Indeed, the evidence suggests that if either changes in the path for short-term interest rates or changes in the growth rates of narrow reserve aggregates are used as indicators of monetary policy, the hypothesis that non-technical discount rate changes signal a change in monetary policy is rejected.

C. An Investigation of Friedman's Hypothesis

The rejection of both the direct effect and the hypothesis that non-technical discount rate changes signal a change in monetary policy necessarily leads to a consideration of Friedman's (1959) hypothesis. The problem is Friedman's hypothesis is not specific. It does not identify the information the market is reacting to when the Fed announces a non-technical discount rate change. Moreover, the precise wording of announcements varies considerably from announcement to announcement, so it is possible, perhaps even likely, that the markets are not

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[20]These equations also included a distributed lag of order 5 on the dependent variable and a time trend.

responding to the same information each time. If this is the case, however, Friedman's hypothesis has the implication that the market's response will vary from announcement to announcement.

To see how this possibility might be investigated, consider the following specification for changes in the interest rate:

$$(13)\quad \Delta i_t = \alpha + \mu \Delta DR_{NT,t} + \epsilon_t \qquad t = 1, 2, \ldots, T,$$

where $\mu\Delta DR_{NT,t}$ represents the response of the interest rate to a change in the discount rate on date t and ϵ_t denotes a market specific or idiosyncratic shock. The parameter α denotes the average response of the interest rate to other general market shocks over the entire period. Equation 13 indicates that the variability of rates on days when there are no discount rate announcements is smaller than on days when there are announcements.

If the information contained in non-technical discount rate announcements is important, the change in interest rates on those days should be larger than on other days, i.e., $\Delta i_t/\sigma_\epsilon$ should be large on announcement days, where σ_ϵ is the standard error of the Δi_t on days when there were no discount rate changes. Moreover, since all markets should respond simultaneously to discount rate announcements, $\Delta i_t/\sigma_\epsilon$ should be simultaneously large for all interest rates unless the idiosyncratic shock in one particular market were sufficiently large to offset the reaction to the news associated with a discount rate change.

A convenient way to investigate this for each non-technical discount rate change is to estimate the equation:

$$(14)\quad \Delta i_t = \alpha + \beta(L)\Delta i_{t-1} + \delta(L)\Delta FR_t + Z_t\mu + \epsilon_t, \qquad t = 1, 2, \ldots, T$$

where Z_t is a 1 x (N+1) vector of observations, $Z_t = (1,0,0,\ldots,\Delta DR_{NT,t},0,\ldots,0)$, and μ is an (N+1) x 1 vector of parameters, $\mu = (\mu_1,\ldots,\mu_N)$. T denotes the number of market days less one in a given calendar period and N denotes the number of non-technical discount rate changes (40). Equation 14 can be thought of as the *unconstrained* version of Equation 11, i.e., Equation 14 is identical to Equation 11 if the constraint $\mu_1=\mu_2=\ldots=\mu_N$ is imposed.

The t-statistic for each μ_j, j = 1, 2,..., N, is $\Delta i_t/\sigma_\epsilon$.[21] The estimates of $\Delta i_t/\sigma_\epsilon$ are presented in Table 12. One striking feature of these results is the extent to which idiosyncratic shocks appear to dominate the information

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[21]This procedure is described more fully in Thornton (1989).

contained in a discount rate announcement. There are comparatively few times when there are large simultaneous responses of the four rates to a discount rate change. Indeed, there were only eight occasions when the federal funds and three Treasury-bill rates responded by 1.5 standard errors or more to a given discount rate announcement. This suggests that the response to discount rate changes is frequently small relative to the idiosyncratic shocks in these markets or perhaps it is the case that markets do not respond in an important way to all non-technical discount rate changes.

These results suggest the possibility that the market responds to information contained in the announcement rather than to the change in the discount rate *per se*. This would account for relative dearth of simultaneous responses, the fact that the magnitude of the response appears to vary significantly from announcement to announcement and that some announcements, such as the one made on October 9, 1979 when the Fed simultaneously announced it was shifting to a nonborrowed reserves operating procedure, seem to elicit a relatively large response in all rates. It would also account for the lack of response to technical discount rate changes: the markets do not react to them because they convey no new information. On average, markets respond to non-technical discount rate changes because on average they convey news, but the response varies considerably from announcement to announcement depending on the news that the announcement contains.

IV. Conclusions

A considerable volume of empirical literature has established that markets react to changes in the Federal Reserve's discount rate and a number of alternative hypotheses for this reaction have been suggested. This paper investigates the reaction of the federal funds rate and the three-, six-, and 12-month Treasury-bill rates to changes in the discount rate and presents the results of tests designed to differentiate among competing hypotheses. The evidence suggests that the market's response is due simply to an announcement effect. The evidence rejects the notion that discount rate changes have a quantitatively important effect on market interest rates because of their direct effect on the supply of money. Consequently, the suggestion that the response to discount rate changes necessarily varies with the Fed's operating procedure [Roley and Troll (1984) and Smirlock and Yawitz (1985)] is rejected.

The evidence presented here also rejects the notion that markets do not respond to technical discount rate changes because they are anticipated. Both technical and non-technical changes tend to follow, rather than lead, the market and the exact timing of either change cannot be anticipated. Consequently, the evidence supports the notion that markets do not respond to technical discount rate changes simply because their announcement provides no information, not because they were anticipated.

The Fed has given a variety of explanations for making non-technical changes in the discount rate, and seldom makes a direct statement of its policy intentions when announcing a discount rate change. Despite this fact, it is often assumed that the market responds to such changes because they "signal" a change in monetary policy. Tests of this hypothesis using both interest rates and reserve measures provide no support for it.

These results are only suggestive, however. Certainly, they cannot rule out the possibility that a particular discount rate change conveyed information about monetary policy. Indeed, casual observation suggests that, at times, discount rate changes convey such information. The most striking example of such an announcement is the one made in October 1979, when the Fed underscored its intent to fight inflation by announcing that it was raising the discount rate a full percentage point and simultaneously announcing its shift to a nonborrowed reserves operating procedure. This announcement was associated with a 225 basis-point change in the federal funds rate and 112, 94 and 90 basis-point changes in the three-, six-, and 12-month Treasury-bill rates, respectively. Moreover, this announcement was associated with a dramatic change in the growth rates of reserves and the monetary base.

Events like these merely serve to illustrate what the evidence suggests, however, namely that markets respond to information in the discount rate announcement and not simply to the news that the discount rate is higher or lower. A detailed analysis of the response to individual discount rate changes indicates that often markets do not appear to respond at all to non-technical discount rate changes or that they do not respond simultaneously. This suggests that the exact nature and anticipated usefulness of the information that such announcements provide varies from announcement to announcement. While caution is required, it seems reasonable that identically worded announcements could engender different responses depending on the circumstances in the market at the time. In summary, the evidence suggests that the market's reaction to a non-technical discount rate change is purely an "announcement effect", that the announcement effect is invariant to the Fed's operating procedures and that changing expectations about monetary policy is not the only reason, indeed, it is not the most important reason, for the market's reaction.

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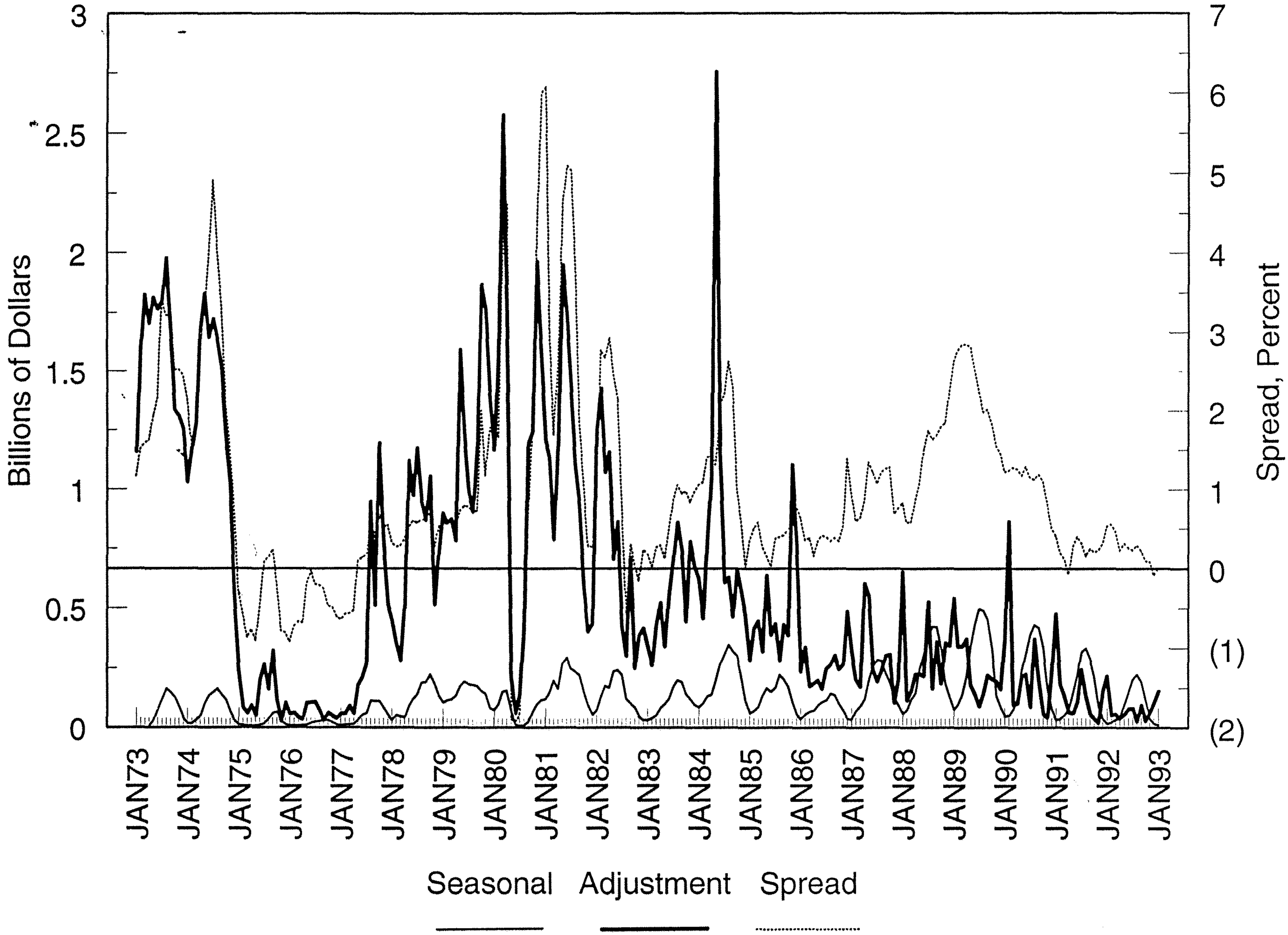
Figure 1: Borrowings and the Spread



Data plotted from January 1973 through January 1993, except for seasonal borrowings which begins in April 1973.

Table 1: Discount Rate Changes and Associated Changes in Market Rates

Date[1/]	Classification	ΔDR	ΔFR	ΔTB3	ΔTB6	ΔTB12
1/15/73	T	0.50	0.125	0.03	0.01	0.03
2/26/73	M	0.50	0.375	0.21	0.19	0.15
4/23/73	T	0.25	-0.500	0.06	0.13	0.10
5/11/73	T	0.25	0.187	0.23	0.16	0.09
6/11/73	M	0.50	0.188	0.08	0.09	0.06
7/2/73	P	0.50	1.125	0.38	0.35	0.31
8/14/73	T	0.50	-0.150	0.23	0.12	0.01
4/25/74	M	0.50	0.950	0.19	0.20	0.11
12/9/74	M	-0.25	0.030	-0.18	-0.22	-0.23
1/6/75	P	-0.50	-0.520	-0.06	-0.11	-0.11
2/5/75	T	-0.50	-1.740	-0.15	-0.13	-0.19
3/10/75	M	-0.50	-0.100	0.06	0.00	0.01
5/16/75	T	-0.25	0.010	0.01	-0.08	-0.08
1/19/76	T	-0.50	-0.030	-0.08	-0.08	-0.11
11/22/76	T	-0.25	-0.060	-0.06	-0.06	-0.06
8/30/77	T	0.50	-0.010	0.02	0.01	0.01
10/26/77	T	0.25	0.110	-0.05	-0.03	-0.02
1/9/78	P	0.50	0.170	0.39	0.35	0.31
5/11/78	T	0.50	0.040	-0.07	0.02	0.00
7/3/78	T	0.25	-0.370	-0.06	-0.05	-0.05
8/21/78	P	0.50	0.200	-0.04	-0.02	-0.05
9/22/78	M	0.25	0.010	0.11	0.15	0.11
10/16/78	M	0.50	0.110	0.06	0.19	0.14
11/1/78	P	1.00	0.520	0.10	0.08	0.03
7/20/79	M	0.50	0.200	0.16	0.12	0.06
8/17/79	P	0.50	-0.030	0.06	0.04	0.05
9/19/79	T	0.50	-0.420	-0.20	-0.22	-0.13
10/9/79	P	1.00	2.250	1.12	0.94	0.90
2/15/80	P	1.00	0.370	0.57	0.58	0.55
5/29/80	T	-1.00	-1.740	0.22	0.24	0.24
6/13/80	T	-1.00	-0.040	-0.02	-0.19	-0.16
7/28/80	T	-1.00	0.340	0.16	0.22	0.20

(more)

Table 1 continued

Date[1/]	Classification	ΔDR	ΔFR	ΔTB3	ΔTB6	ΔTB12
9/26/80	M	1.00	0.690	0.46	0.45	0.37
11/17/80	M	1.00	1.990	0.80	0.76	0.61
12/5/80	M	1.00	1.210	0.98	0.39	0.21
5/5/81	M	1.00	-0.280	0.60	0.54	0.49
11/2/81	T	-1.00	0.620	-0.06	-0.03	-0.09
12/4/81	T	-1.00	-0.820	-0.58	-0.66	-0.62
7/20/82	M	-0.50	-0.870	-0.40	-0.25	-0.32
8/2/82	M	-0.50	-0.580	-0.81	-0.62	-0.48
8/16/82	M	-0.50	-0.470	-0.58	-0.42	-0.35
8/27/82	T	-0.50	0.550	0.70	0.57	0.58
10/12/82	T	-0.50	-0.430	-0.37	-0.52	-0.47
11/22/82	M	-0.50	-0.270	-0.14	-0.06	-0.07
12/14/82	P	-0.50	-0.440	-0.32	-0.37	-0.30
4/9/84	T	0.50	-0.050	-0.09	-0.03	-0.05
11/23/84	P	-0.50	-0.350	-0.10	-0.11	-0.07
12/24/84	M	-0.50	-0.530	-0.13	-0.03	-0.06
5/20/85	M	-0.50	-0.250	-0.14	-0.16	-0.22
3/7/86	M	-0.50	-0.270	-0.08	-0.08	-0.06
4/21/86	T	-0.50	0.290	0.00	0.04	0.03
7/11/86	T	-0.50	-0.310	-0.10	-0.08	-0.10
8/21/86	P	-0.50	-0.300	-0.13	-0.14	-0.11
9/4/87	P	0.50	0.010	0.19	0.24	0.12
8/9/88	M	0.50	-0.050	0.22	0.16	0.10
2/24/89	P	0.50	0.190	0.04	0.13	0.03
12/19/90	M	-0.50	-0.240	-0.11	-0.13	-0.12
2/1/91	P	-0.50	-1.880	-0.19	-0.23	-0.22
4/30/91	M	-0.50	0.050	-0.08	-0.14	-0.14
9/13/91	M	-0.50	-0.220	-0.06	-0.05	-0.03
11/6/91	M	-0.50	-0.190	-0.13	-0.11	-0.08
12/20/91	M	-1.00	-0.490	-0.30	-0.29	-0.26
7/2/92	P	-0.50	-0.430	-0.31	-0.29	-0.32

[1/] Indicates the date that market rates responded to the discount rate change--not the day of the announcement.

Table 2: Average Absolute Change in Market Interest Rates Over Different Operating Procedures				
Sub-Periods	ΔFR	ΔTB3	ΔTB6	ΔTB12
1/3/72-10/8/79	0.213	0.068	0.058	0.053
10/9/79-10/11/82	0.591	0.212	0.188	0.160
10/12/82-1/29/93	0.195	0.048	0.049	0.047

Table 3: Tests for the Equality of Response Over Different Operating Procedures				
Parameters	ΔFR	ΔTB3	ΔTB6	ΔTB12
α	-0.018 (1.31)	0.004 (0.32)	0.004 (0.32)	0.002 (0.15)
μ^1_{NT}	0.405* (4.46)	0.218* (4.83)	0.208* (5.67)	0.153* (4.26)
μ^2_{NT}	1.201* (4.94)	0.727* (7.07)	0.562* (6.11)	0.489* (6.20)
μ^3_{NT}	0.501* (5.66)	0.274* (8.67)	0.281* (8.75)	0.237* (7.81)
μ^1_T	-0.000 (0.00)	0.033 (0.60)	0.025 (0.53)	0.054 (1.19)
μ^2_T	0.259 (0.94)	-0.018 (0.15)	0.013 (0.12)	0.009 (0.10)
μ^3_T	0.099 (0.42)	0.008 (0.10)	0.009 (0.11)	0.019 (0.24)
$\bar{R}^2$	0.091	0.060	0.054	0.048
F $\mu^1_{NT} = \mu^2_{NT}$	9.421*	20.611*	12.800*	15.093*
F $\mu^2_{NT} = \mu^3_{NT}$	7.312*	17.727*	8.367*	8.943*
Estimated Standard Errors				
Settlement Wed. and Thur.	0.636			
First and Last Day of Year	1.650			
1/3/72 - 5/13/73	0.198	0.059	0.059	0.053
5/14/73 - 4/30/75	0.274	0.171	0.128	0.107
5/1/75 - 10/7/79	0.117	0.079	0.063	0.063
10/8/79 - 10/5/82	0.638	0.268	0.239	0.204
10/6/82 - 12/11/90	0.207			
12/12/90 - 3/28/91	0.527			
3/29/91 - 1/29/93	0.169			
10/6/82 - 1/29/93		0.071	0.072	0.068

(more)

Table 3 (continued)

	ΔFR	ΔTB3	ΔTB6	ΔTB12
α	-0.016 (1.14)	0.005 (0.37)	0.006 (0.45)	0.004 (0.30)
μ^1_{NT}	1.979* (4.45)	3.265* (4.89)	3.675* (5.77)	2.977* (4.38)
μ^2_{NT}	2.100* (4.83)	3.003* (6.07)	2.605* (5.24)	2.796* (5.59)
μ^3_{NT}	2.601* (5.74)	5.812* (8.98)	5.870* (9.01)	5.101* (8.06)
μ^1_T	0.178 (0.30)	0.572 (0.70)	0.531 (0.66)	1.095 (1.28)
μ^2_T	0.153 (0.29)	-0.161 (0.29)	0.008 (0.02)	0.014 (0.03)
μ^3_T	0.587 (0.47)	0.231 (0.14)	0.212 (0.13)	0.415 (0.25)
R^2	0.112	0.063	0.056	0.046
F $\mu^1_{NT} = \mu^2_{NT}$	0.038	0.100	1.765	0.046
F $\mu^2_{NT} = \mu^3_{NT}$	0.635	11.961*	15.939*	8.204*

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

Table 4: Results of Direct Tests for the Predictability of Technical and Non-Technical Discount Rate Changes

	Technical		Non-Technical	
Const.	-0.012*	(3.78)	-0.007	(1.47)
$Spread_{t-1}$	0.022*	(3.26)	0.038*	(4.02)
$Spread_{t-2}$	-0.025*	(2.69)	-0.008	(0.62)
$Spread_{t-3}$	0.032*	(3.49)	-0.023	(1.80)
$Spread_{t-4}$	-0.022*	(3.15)	0.002	(0.21)
$Borr_{t-1}$	0.009	(1.22)	0.008	(0.72)
$Borr_{t-2}$	0.022*	(2.69)	-0.004	(0.38)
$Borr_{t-3}$	0.016	(1.91)	-0.003	(0.30)
$Borr_{t-4}$	0.018*	(2.44)	0.000	(0.03)
S.E.	0.085		0.118	
$\bar{R}^2$	0.045		0.024	
F[1/]	7.398*		4.368*	

Tests of Predictability Using Daily Data

Interest Rate	Type of Discount Rate Change	Value of k: 5	10	15
FR	Technical	0.842	0.879	1.106
	Non-Technical	0.438	3.063*	2.511*
TB3	Technical	1.966	1.739	2.025*
	Non-Technical	10.181*	5.433*	4.083*
TB6	Technical	3.352*	2.692*	2.796*
	Non-Technical	10.438*	5.904*	4.331*
TB12	Technical	3.695*	2.832*	3.034*
	Non-Technical	11.447*	6.559*	4.735*

[1/] F-statistic for a test of the null hypothesis that all of the coefficients except the constant are zero.

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

Table 5: Response to "Pure" and "Mixed" Non-Technical Discount Rate Changes

Variable	ΔFR	ΔTB3	ΔTB6	ΔTB12
α	-0.018 (1.34)	0.005 (0.40)	0.004 (0.31)	0.002 (0.16)
μ_M	0.468* (5.91)	0.284* (8.55)	0.267* (8.41)	0.227* (7.60)
μ_P	0.560* (5.69)	0.281* (7.28)	0.271* (7.89)	0.221* (6.62)
$\bar{R}^2$	0.089	0.057	0.055	0.047
F[1/]	0.530	0.004	0.007	0.021
Estimated Standard Errors				
Settlement Wed./Thurs.	0.637			
First and last days of the year	1.650			
1/3/72-5/13/73	0.197	0.059	0.059	0.054
5/14/73-4/30/75	0.272	0.171	0.128	0.107
5/1/75-10/7/79	0.119	0.080	0.064	0.064
10/8/79-10/5/82	0.639	0.269	0.240	0.205
10/6/82-12/11/90	0.208			
12/12/90-3/28/91	0.522			
3/29/91-1/29/93	0.172			
10/6/82-1/29/93		0.071	0.071	0.068

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

[1/] F Test of the null hypothesis that $\mu_P = \mu_M$.

Table 6: Estimates of the Demand for Borrowed Reserves

	Adjustment Borrowing Equation		Seasonal Borrowing Equation	
	May 1973 - June 1984	July 1984 - January 1993	May 1973 - June 1984	July 1984 - January 1993
Const.	0.508* (8.55)	0.171* (2.79)	-0.046* (2.01)	0.074* (2.63)
Sp	0.414* (8.85)	0.169 (1.48)	0.018* (4.23)	-0.004 (0.21)
Sp_2	-0.037 (3.65)	-0.038 (0.89)	-0.000 (1.13)	0.000 (0.04)
$\bar{R}^2$	0.777	0.252	0.897	0.962
θ_1	0.527* (7.18)	0.477* (5.51)	1.151* (13.74)	1.468* (18.19)
θ_2			-0.242* (2.89)	-0.574* (7.11)
SE	0.290	0.172	0.023	0.024

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

These equations were estimates using an exact (Prais-Winsten) AR adjustment. That is $\Sigma_t = \theta_1 \Sigma_{t-1} + \theta_2 \Sigma_{t-2} + U_t$.

Table 7: The Response to Non-Technical Discount Rate Changes, Pre- and Post-June 1984				
Parameter	ΔFR	ΔTB3	ΔTB6	ΔTB12
α	-0.019 (-1.37)	0.005 (0.33)	0.004 (0.31)	0.002 (0.15)
Pre-June 1984	0.531* (6.43)	0.318* (8.25)	0.270* (8.27)	0.224* (7.19)
Post-June 1984	0.472* (5.09)	0.257* (7.74)	0.269* (8.03)	0.225* (7.07)
R^2	0.089	0.058	0.055	0.047
F[1/]	0.224	1.450	0.001	0.001
Estimated Standard Errors				
Settlement Wed./Thur.	0.637			
1st and last days of year	1.650			
1/3/72-5/13/73	0.197	0.059	0.059	0.054
5/14/73-4/30/75	0.273	0.171	0.129	0.107
5/1/75-10/7/79	0.120	0.080	0.064	0.064
10/8/79-10/5/82	0.638	0.269	0.240	0.204
10/6/82-12/11/90	0.208			
12/12/90-3/28/91	0.527			
3/29/91-1/29/93	0.169			
10/6/82-1/29/93		0.071	0.071	0.067

[1/] F-statistic for a test of the null hypothesis that Pre-June = Post-June.
* Indicates statistical significance at the 5 percent level. Absolute value of t-statistic in parentheses.

Table 8: Tests for a Shift in the Drift of the Federal Funds Rate

Parameter	ΔFR			
	K=5	K=10	K=15	K=20
Const.	-0.017 (1.22)	-0.022 (1.51)	-0.021 (1.43)	-0.017 (1.12)
λ_b(Pos)	0.033 (1.49)	0.046* (3.00)	0.034* (2.58)	0.033* (2.71)
λ_a(Pos)	0.154* (6.77)	0.126* (7.85)	0.090* (6.62)	0.066* (5.83)
λ_b(Neg)	-0.063* (2.54)	-0.052* (2.91)	-0.035* (2.40)	-0.033* (2.51)
λ_a(Neg)	-0.139* (5.22)	-0.095* (5.16)	-0.076* (4.97)	-0.072* (5.51)
R^2	0.092	0.097	0.095	0.095
F(Pos)	15.153*	11.737*	6.668*	3.078
F(Neg)	4.409*	2.814	3.446	3.896*
Estimated Standard Errors				
Settlement Wed./Thur.	0.634	0.634	0.636	0.636
1st/last day of year	1.653	1.652	1.649	1.707
1/3/72-5/13/73	0.193	0.196	0.197	0.201
5/14/73-4/29/75	0.275	0.276	0.273	0.274
4/30/75-10/7/79	0.123	0.121	0.120	0.120
10/8/79-10/5/82	0.640	0.640	0.644	0.646
10/6/82-12/11/90	0.209	0.209	0.209	0.208
12/12/90-3/28/91	0.523	0.526	0.529	0.534
3/29/91-1/29/93	0.174	0.171	0.170	0.171
10/6/82-1/29/93				

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

Table 9: Further Tests for a Shift in the Drift of the Federal Funds Rate

Parameter	ΔFR			
	K=5	K=10	K=15	K=20
Const.	-0.020 (1.41)	-0.021 (1.50)	-0.022 (1.48)	-0.018 (1.20)
λ_b(Pos)	0.033 (1.53)	0.043* (2.78)	0.039* (2.96)	0.036* (3.06)
λ_a(Pos)	0.134* (6.00)	0.103* (6.39)	0.071* (5.32)	0.057* (5.08)
λ_b(Neg)	-0.062* (2.47)	-0.052* (2.90)	-0.037* (2.51)	-0.034* (2.60)
λ_a(Neg)	-0.071* (2.59)	-0.069* (3.71)	-0.056* (3.58)	-0.059* (4.47)
$\bar{R}^2$	0.086	0.091	0.090	0.092
F(Pos)	11.068*	6.300*	2.209	1.139
F(Neg)	0.059	0.406	0.684	1.537
Estimated Standard Errors				
Settlement Wed./Thur.	0.635	0.634	0.636	0.636
1st/last day of year	1.653	1.652	1.650	1.707
1/3/72-5/13/73	0.197	0.197	0.200	0.202
5/14/73-4/29/75	0.280	0.277	0.274	0.275
4/30/75-10/7/79	0.117	0.120	0.118	0.118
10/8/79-10/5/82	0.651	0.647	0.649	0.649
10/6/82-12/11/90	0.209	0.209	0.209	0.208
12/12/90-3/28/91	0.539	0.536	0.536	0.538
3/29/91-1/29/93	0.173	0.172	0.171	0.172

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

Table 10: Tests for a Shift in the Drift of the T-Bill Rates

Parameter	$\Delta TB3$				$\Delta TB6$				$\Delta TB12$			
	K=5	K=10	K=15	K=20	K=5	K=10	K=15	K=20	K=5	K=10	K=15	K=20
Const.	0.006	0.010	0.007	0.008	-0.000	0.005	0.001	0.000	-0.003	0.004	0.001	-0.002
	(0.44)	(0.71)	(0.47)	(0.51)	(0.00)	(0.35)	(0.10)	(0.02)	(0.20)	(0.25)	(0.03)	(0.16)
λ_b(Pos)	0.032*	0.016*	0.014*	0.012*	0.034*	0.019*	0.014*	0.010*	0.040*	0.023*	0.017*	0.013*
	(3.38)	(2.40)	(2.43)	(2.29)	(4.21)	(3.30)	(2.80)	(2.38)	(5.16)	(4.17)	(3.51)	(3.01)
λ_s(Pos)	0.016	0.010	0.017*	0.014*	0.028*	0.016*	0.018*	0.015*	0.017*	0.008	0.011*	0.009*
	(1.64)	(1.46)	(2.93)	(2.80)	(3.34)	(2.53)	(3.59)	(3.48)	(2.12)	(1.32)	(2.31)	(2.29)
λ_b(Neg)	-0.026*	-0.016*	-0.016*	-0.011*	-0.025*	-0.019*	-0.016*	-0.009*	-0.021*	-0.017*	-0.015*	-0.009*
	(3.04)	(2.69)	(3.12)	(2.40)	(3.00)	(3.20)	(3.24)	(2.13)	(2.66)	(3.11)	(3.23)	(2.08)
λ_s(Neg)	-0.021*	-0.018*	-0.013*	-0.014*	-0.014	-0.015*	-0.010*	-0.010*	-0.012	-0.014*	-0.008	-0.008
	(2.49)	(3.01)	(2.60)	(3.16)	(1.64)	(2.44)	(1.98)	(2.31)	(1.48)	(2.54)	(1.71)	(1.90)
$\bar{R}^2$	0.039	0.039	0.041	0.041	0.038	0.037	0.038	0.037	0.035	0.035	0.035	0.034
F(Pos)	1.353	0.339	0.132	0.078	0.225	0.158	0.333	0.413	4.211*	3.357	0.519	0.259
F(Neg)	0.132	0.071	0.115	0.217	0.911	0.255	0.722	0.007	0.694	0.137	1.062	0.027
Estimated Standard Errors												
1/3/72-5/13/73	0.060	0.060	0.061	0.060	0.059	0.060	0.059	0.059	0.054	0.054	0.054	0.053
5/14/73-4/30/75	0.171	0.172	0.172	0.171	0.130	0.130	0.130	0.130	0.108	0.108	0.108	0.108
5/1/75-10/7/79	0.080	0.079	0.079	0.079	0.063	0.063	0.063	0.063	0.063	0.063	0.063	0.063
10/8/79-10/5/82	0.274	0.275	0.275	0.275	0.243	0.244	0.244	0.244	0.208	0.208	0.208	0.208
10/6/82-1/29/93	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.072	0.068	0.068	0.068	0.068

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

Table 11: Tests for a Significant Shift in the Growth Rates of Selected Reserve Aggregates

Parameter	Variable		
	MB	TR	NBR
Const.	13.157* (7.07)	52.501* (5.04)	184.621* (5.52)
λ_b(Pos)	9.057* (2.81)	37.761 (1.95)	145.378* (2.65)
λ_a(Pos)	12.388* (3.85)	41.064* (2.15)	137.606* (2.55)
λ_b(Neg)	10.225* (3.02)	9.126 (0.45)	86.598 (1.46)
λ_a(Neg)	16.238* (4.73)	20.642 (1.00)	90.119 (1.52)
R^2	0.322	0.235	0.066
F(Pos)	0.469	0.013	0.010
F(Neg)	1.551	0.134	0.002

* Indicates statistical significance at the 5 percent level. Absolute value of t-statistics in parentheses.

Table 12: Estimates of $\Delta i/\sigma_\varepsilon$ for Non-technical Discount Rate Changes

Discount Rate Change	ΔFR	ΔTB3	ΔTB6	ΔTB12
2/26/73	1.995*	3.504*	3.221*	2.605*
6/11/73	0.805	0.489	0.654	0.530
7/2/73	4.361*	1.957*	2.388*	2.515*
4/25/74	1.430	0.936	1.414	0.925
12/9/74	0.157	0.902	1.744*	2.100*
1/6/75	1.862*	-0.050	0.662	0.853
3/10/75	0.488	-0.356	0.037	-0.085
1/9/78	1.180	4.963*	5.581*	4.851*
8/21/78	2.050*	-0.596	-0.446	-0.948
9/22/78	0.325	1.463	2.389*	1.723*
10/16/78	0.756	0.742	3.034*	2.188*
11/1/78	0.916	1.004	0.628	0.078
7/20/79	1.966*	1.920*	1.791*	0.828
8/17/79	0.383	0.776	0.625	0.690
10/9/79	3.578*	3.962*	3.694*	4.165*
2/15/80	0.699	1.874*	2.116*	2.393*
9/26/80	1.288	1.445	1.624*	1.563*
11/17/80	3.207*	2.746*	2.813*	2.615*
12/5/80	2.295*	3.421*	1.504*	0.909
5/5/81	0.082	1.775*	1.669*	1.946*
7/20/82	1.820*	1.441	0.788	1.273
8/2/82	0.854	2.849*	2.406*	2.181*
8/16/82	0.858	1.937*	1.478	1.510*
11/22/82	1.755*	1.439	0.334	0.671
12/14/82	2.030*	4.507*	5.028*	4.250*
11/23/84	0.592	1.095	1.044	0.546
12/24/84	2.809*	1.748*	0.220	0.720
5/20/85	1.174	1.999*	2.248*	3.257*
3/7/86	1.498	0.822	0.903	0.605
8/21/86	1.586*	1.657*	1.836*	1.455
9/4/87	0.054	2.451*	3.448*	1.560*
8/9/88	-0.140	3.175*	2.267*	1.437

(more)

Table 12 continued				
Discount Rate Change	ΔFR	ΔTB3	ΔTB6	ΔTB12
2/24/89	1.198	0.316	1.570*	0.131
12/19/90	0.456	1.416	1.734*	1.667*
2/1/91	3.367*	2.389*	2.889*	2.950*
4/30/91	-0.306	1.118	1.992*	2.119*
9/13/91	1.396	0.727	0.602	0.319
11/6/91	1.158	1.815*	1.584*	1.226
12/20/91	2.762*	3.938*	3.843*	3.699*
7/2/92	2.552*	4.274*	4.059*	4.694*

Estimated Standard Errors				
	Variable			
Subsample	ΔFR	ΔTB3	ΔTB6	ΔTB12
Settlement Wed. and Thurs.	0.637			
First and last day of year	1.651			
1/3/72 - 5/13/73	0.197	0.059	0.059	0.054
5/14/73 - 4/30/75	0.269	0.170	0.128	0.106
5/1/75 - 10/7/79	0.115	0.078	0.062	0.062
10/8/79 - 10/5/82	0.630	0.267	0.239	0.203
10/6/82 - 12/11/90	0.207			
12/12/90 - 3/28/91	0.504			
3/29/91 - 1/29/93	0.167			
10/6/82 - 1/29/93		0.071	0.071	0.067

* Indicates t-statistic ≥ 1.50.